



Alagnak

Aniakchak

Katmai

Kenai Fjords

Lake Clark

# Forest Insects and Disease

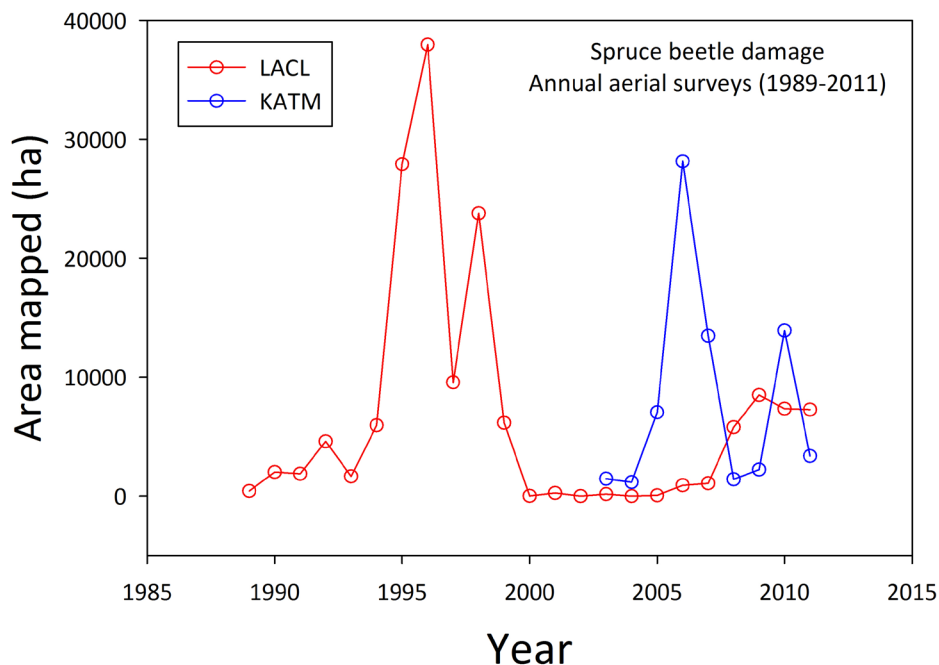
## Recent spruce beetle outbreaks impact large areas of south central Alaska

Over the last two decades, roughly 1.5 million hectares of forest in south central Alaska has been killed by the spruce beetle (*Dendroctonus rufipennis*). Since 2008, there has been an increase in spruce beetle activity in Lake Clark NPP (LACL), primarily around Lake Clark, Kontrashibuna, and Upper Tazimina. Beetle activity in Katmai NPP (KATM)

has also increased, mainly around Lake Brooks. In addition, spruce needle rust (*Chrysomyxa ledicola*) outbreaks in 2008, 2011, and 2012 have temporarily affected broad swaths of remaining live spruce (U.S. Forest Service 2013). Native defoliators (e.g., geometrid moths, noctuid moths) have affected alder, willow, and dwarf birch in shrublands as far west as Dillingham.



**SWAN cooperater, Dr. Rosemary Sheriff, collects a tree core to analyze for periods of growth and stress.**



**Figure 1. Mapped area (hectares) affected by spruce beetle annually in Lake Clark (LACL) and Katmai (KATM). Data are from U.S. Forest Service aerial surveys (1989-2011; <http://agdc.usgs.gov/data/projects/fhm/#L>) and reflect the areas where surveys were flown rather than total land area affected.**



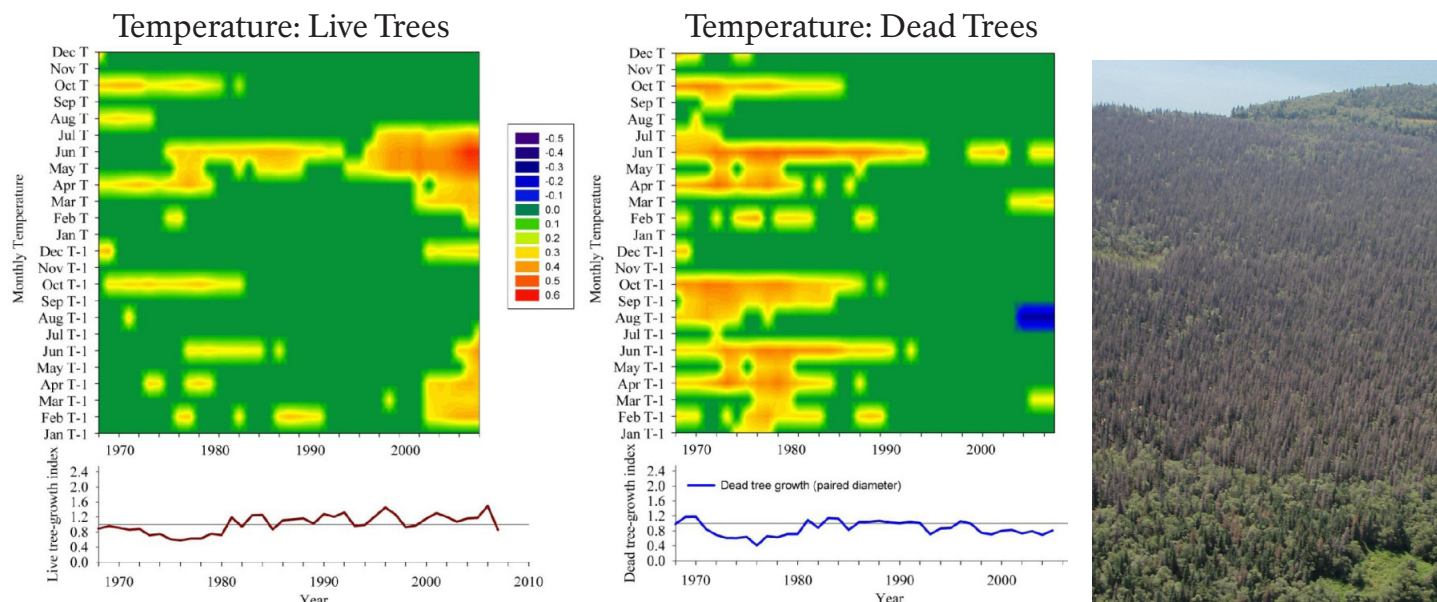
**Left: SWAN biotech Evan Heck takes measurements in a vegetation plot. These plots are being used to track vegetation responses in the areas hardest hit by spruce beetle outbreaks.**

## Monitoring Approach

To better understand long-term forest disturbance dynamics, SWAN is using tree-ring data to examine the frequency of spruce beetle outbreaks in LACL and KATM as well as the relationship between climate and beetle outbreaks regionally. Annual aerial surveys conducted by the U.S. Forest Service and state Department of Natural Resources are being used to track general trends in beetle activity (U.S. Forest Service 2013; Fig. 1), and plot measurements are being used to monitor vegetation response at the hardest-hit sites.

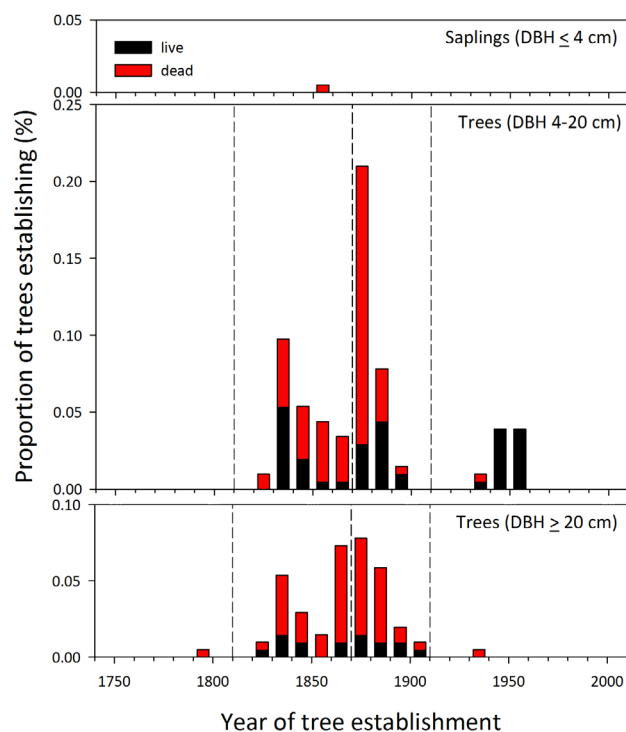
## Importance

Insect outbreaks have led to widespread mortality in the forests of south central and southwest Alaska. These dieback events, in turn, may result in broad-scale changes in forest structure and composition, including changes in understory species composition.



**Figure 2.** A moving correlation between temperature and growth for a site in KATM shows that the first trees to be killed by the spruce beetle were those that had been most sensitive to warming in the 1970s and 1980s (R. Sherriff, unpublished data). The X-axis shows years from 1968-2006, and the Y-axis shows the correlation between temperature and growth for months one year prior to (T-1) and in the year of (T) growth. Warm colors indicate a positive correlation between temperature and growth, cool colors a negative correlation, and green no correlation. In trees that survived the spruce beetle outbreak (left), tree growth was relatively insensitive to temperature up until the mid-1990s. In contrast, trees that were killed by the spruce beetle in the mid-2000s (right) showed a strong positive response to temperature in both the year prior to and the year of growth. After the mid-1990s, tree growth became decoupled from temperature in the trees that died (right), whereas growth was enhanced by warming in the trees that survived (left). The aerial photograph (right of Fig. 2) taken while flying over Katmai National Park and Preserve shows a large area of beetle-defoliated trees.

## Tracking historical patterns of growth and stress in response to warming



**Figure 3.** Composite age structure for forest sites in LACL and KATM (n=10). On average, 75% of trees sampled at these sites were already dead (shown in red) in 2009-2010, and a few sites showed nearly 100% mortality. Roughly one-third of trees sampled were old, large-diameter trees, and most of these had been killed by the spruce beetle. However, we also found many older trees, both live and dead, in the smaller size classes (<20 cm). Outbreak periods in the 1810s, 1870s, and 1910s are shown by vertical dashed lines; a major establishment event occurred in the 1880s, following the 1870s outbreak.

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Tree-ring data from the Alaska and Kenai Peninsulas show that widespread forest thinning has occurred at roughly 50 year intervals over the last 250 years (Sherriff et al. 2011; Fig. 3). Major growth releases associated with beetle outbreaks appear in the tree-ring record in the 1810s, 1870s, 1910s, and 1970s-1980s, often following a series of warmer and drier than average years (Sherriff et al. 2011). Trees killed by the spruce beetle often show greater sensitivity to temperature in the decades before beetle attack than trees that initially survived (Sherriff et al., unpublished data; Fig. 2). This finding is supported by a collaborative study with the University of Alaska and Humboldt State University, which is using stable isotopes of carbon and oxygen in tree rings to look for evidence for drought stress prior to tree death. As trees become stressed, their stomata close to reduce evaporative water loss and as a result restrict the movement of CO<sub>2</sub> into the leaf. The 'signature' of that restricted movement is observed in the carbon and oxygen isotope values, both of which increase with water stress. Forest monitoring plots are being used to track changes in stand structure and composition associated with the recent beetle-kill.